DISCOVERY

# An assessment of gully erosion in Dutse Metropolis, Jigawa state Nigeria

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## ABSTRACT

This study examines gully erosion in Dutse metropolis which is an area that has many gully erosion sites. A total of three gully erosion sample sites were randomly selected for the study. Field measurement and laboratory analysis were used to generate data for the study. The findings revealed that gully erosion has been the result of combined factors of natural and anthropogenic factors. The natural factors include heavy rainfall, wind and flood; while the anthropogenic factors are deforestation, overgrazing and intensive farming practice that has affects the landscape to a very large extent. In fact, about 40% of the area has been degraded, 25% are caused by gully erosion and destroyed large portion of farmlands, villages, trees, crops and roads. It has been observed that the gully erosion caused substantial soil losses and water due to the occurrence of heavy rainfall over the years. Plant of different species grow in and around the gullies was evident. Similarly, a drip of water of approximately 0.5%, 0.01% and 0.3% flowing down the gully has been observed and encouraged a minute sediment deposition at the down slope of the gullies and channel entrenchment. However, the prevalence of laterite soil at the down slope of the gully is evident in Maranjuwa. The study found that in Gandun fawa the nature of the soil is sandy and ranged from white through brown within the gully wall. The study concludes that the menace of gully erosion produced badland topography in the study area, destruction of habitats located around the gullies, reduction of land availability and makes crop cultivation extremely difficult.

**Key words:** Gully erosion, rainfall, wind, flood, deforestation, overgrazing intensive farming practice.

## 1. INTRODUCTION

Gully erosion has been an area of study for many researchers, the study of literature on gully erosion indicates that Gully erosion is an essential soil degradation practice in a series of environments, there by generating huge amount of sediment and causing significant soil losses, Poesen, Nachtergaele, Verstraeten and Valentin (2002). Similarly, Casali, Bennett, and Robinson (2002) argued that head cut growth emerged to be the major factor triggering gully erosion mostly in typical discontinuity gullies.

Zegeye, Langedoen, Stoof, Triahum, Dagnew, Zimale, Guzman, Yitaferu, and Steenhuis (2016) reported that in sub humid Ethiopia highlands, the development of gully is initiated with the incidence of infiltration which brings about high pore- water



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forces which lead to discharge and eventually result to the formation of gully. In addition, soil properties and its nature contributed tremendously in the development of gully.

Afegbua, Uwazuruonye and Jafaru (2016) stated that gully erosion is a highly noticeable type of soil erosion that impinge on soil productivity, hamper land use and threaten human life, roads, structures, and fence among others. It is a severe form of soil dreadful condition that frequently involves a preliminary opening in to the sub surface by accumulation of runoff along the lines of weakness e.g. crack, stress and desiccation.

Scholars have become increasingly fascinated in the study of gully erosion in recent years. Although, their attempts to understand the behavior of gully erosion are based on a number of different reasons. Three emerged to be the most important. The first is to ascertain the nature, causes and processes responsible for the formation as well as the impacts of gully erosion, second is to find out the characteristics of the gully and soil properties and; third is to study the vulnerability of soil to gully erosion and the amount of soil losses and water as well as the rate of sediment production caused by gully erosion. Though, this has remained a subject of debate among scholars.

The main objective of such previous studies was to develop appropriate and scientific remedial action to avert the menace and devise management strategies that could last for a life time. Gully erosion strongly affects farmlands, routes of communication, trees, crops, infrastructural facilities and utilities and ultimately settlements, soil losses and water Mansur, (2014; Dube, Nhapi, Murwira, Gumindoga, Goldin, and Mashauri, 2014; Baets, Quine, and Poesen, 2014). A better understanding of the nature of gully erosion, causes, effects and processes as well as human adjustment is therefore a key challenge to geomorphologies, civil engineers, earth scientist and posed a dilemma to geoscientist, land surveyors and other environmental scientist.

The impact of gully erosion particularly in the tropics, is therefore well documented in the literature (Conoscenti, Angileri, Cappadonia, Rotigliano, Agnesi, and Marker, 2014; Torri, and Poesen, 2014; Boardman, 2014; Paolo, Desmond, Antonina, 2014). Similarly, Valentin, Poesen, and Li, (2005) observed that over the years, the main concern was to explore and tackle agricultural problems at the plot scale and thus to rill and inter-rill erosion. The development of gully erosion encompasses three dimensional nature exaggerated by wide range of processes and factors. Gully erosion, is usually caused by the combine action of severe climatic episode and land use change. Similarly, the outcome habitually emerged from the lengthy past antecedent that cannot be ignored when trying to realize spatial erosion model.

Addis, Adugna, Gebretsadik, and Ayalew, (2015) argued that realizing gully structure is the first step in the assessment and method of gully commencement. Gully can take place where the erosion is vigorously affecting the landscape owing to head cut retreat.

Chimnonyerem, (2013) reported that gullies are the result of hydro-chemical, hydro-technical and hydro-geological properties of rocks in the affected area. It also result from background location of the region, in Anambra State, south-eastern Nigeria for example, gully erosion has been very dynamic and overpowered a lot of control measures put in place by local communities, interested groups and Nigeria in general.

Oyegun, Erekaha, and Eludoyin, (2016) observed that gully erosion which involves many geomorphological processes shape the gradient and valley bottom globally in recent years. Gullies are the antecedent of the wearing a way of soil by running water and the quantity of erosion depends on a conglomeration of different factors such as the influence of rain to cause erosion and the capacity of the soil to defy the rain impact.

Valentin, (2005) reported that in the Chinese Loes plateau for example, about 60% -70% of the entire sediment production are the result of the combine action of gully and rill erosion. However, similar proportion has been reported in the Northwestern upland of Ethopia, so also, in mountainous areas gully are found to be a common features and latest example can be seen in Kenya and Morocco. Little attention is paid to the development of knowledge in this field of study of particular mention is the menace of gully erosion in the study area and how this incidence create a very serious threat to the populace. This study therefore, aimed at unfolding the nature of gully erosion in Dutse, Jigawa State with more emphasis to three selected villages' i.e Maranjuwa, Gandun Fawa and Kargo that have over the years been under the threat of gully erosion and its associated impact.

## 2. THE STUDY AREA

Dutse is the capital city of Jigawa State located in the Northern part of Nigeria between latitude 11'44.2N and longitude 09'21.58E. It covers a total land area of about 22,410 square km and has a population of about 251,135 people; while the total population of Jigawa State stands at 4,361,002 (National Bureau of Statistics, 2012). Statistical analysis revealed that the mean annual temperature is about $27^0$C with an annual rainfall of 1000-1,200mm. However, the area has only two seasons (rainfall season and dry season) and there is a clear distinction between the two seasons. The rainfall season usually commences from May-September and end early



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October in some occasions, the remaining part of the year is dry. Mansur and Muhammad (2016) reported that the nature of the soil is sandy and different types of rocks dominate the study area which varies considerably in texture, colour, porosity or permeability and mode of occurrence with varying degree of resistance to erosion.

## 3. MATERIALS AND METHODS

The study area has large number of gully erosion sites, out of which three gully erosion sites were randomly selected for the study namely, Maranjuwa, Gandun Fawa and Kargo. The justification for their selection is that the three aforementioned settlements have for long been under the constant menace of this calamity. Field measurement was conducted at a regular interval during the 2015-2019 rainy season (July- September) each year with a view to understand the behavior of the gullies and laboratory analyses were used to generate data for the study. Morphological variables of the gullies such as length, width and depth were carried out and recorded manually. Data were analyzed through laboratory analysis of soil samples collected from three different study locations.

## 4. RESULTS AND DISCUSSION

The findings of the study through laboratory analysis indicate that the soil in the entire three research sites is vulnerable to the danger of gully erosion having high proportion of sand fraction. In Maranjuwa for instance, sandy 77.4% (96-22 μm), silt 23.6% (11-2 μm); Gandun Fawa is sandy silt 62.1% (93-20 μm), silt 20.1% (19-2 μm) while in Kargo, sandy 81.6% (99-24 μm) was found.

Gully erosion in the study area has been the results of combined factors of natural and anthropogenic factors. The natural factors include heavy rainfall, wind and flood; while the anthropogenic factors are deforestation, overgrazing and intensive farming practice which affects the landscape to a very large extent. In fact, about 40% of the land has been degraded and 25% are caused by gully erosion. It has been observed that the woodland has been washed out due to the action of both natural and human activities making the area susceptible to gully erosion, soil erosion, wind, and desert encroachment.

Findings further indicates that the nature of the soil is sandy and dry, by origin this type of soil has very low surface area, poor structure, and vulnerable to the impact of gully erosion. This, therefore, facilitated percolation and infiltration which enhance the formation of the gullies. This incidence considerably destroys settlements, farm lands, trees and crops, routes of communication in all the three study areas and reduces agricultural productivity as well as land availability, important ecosystems have become degraded and fragmented creating untold hardship to both flora and fauna. This therefore, makes road transportation very difficult especially the road linking Gandunfawa to Bukka village, Kargo to Maratayi, Maranjuwa to Yina, Janbo and Limawa villages among others.

The mean gully depth was 18.9m, gully width 37.25m and gully length is 181.63m. The gully started as a small trench and later developed in to gully. Its rapid evolution has been accelerated by human induced activities which adversely affect the stability of the surface layer and further accentuated by natural factors such as heavy down pour and flood, consequently resulted to soil losses and water (figure 1.) However, about 167-174Kg$^2$ of soil losses and water has been apparent during this year's raining season, plant of different species grow in and around the gully was evident. Similarly, a trickle of water of approximately 0.1% flowing down the gully has been observed and encouraged a minute sediment deposition at down slope of the gully and channel entrenchment.

The commencement of the gully and enlargement in this area has its origin largely due to change in gradient in response to human induce vegetation change. The erosion of the embankment, the initiation and phenomenal advance of the gully was a product of a long period of evolution (figure 2). The gully is about 15.7m depth, 30.22m wide and 143.71m length, in the down slope of the gully laterite soil has been observed due to leaching resulting from heavy rainfall experienced over the years. Most of the nutrients are lost and therefore does not favor agricultural productivity.

Plants species have been apparent inside and outside of the gully, a drop of water of approximately 0.01% flowing down the gully was also evident. Similarly, between 80-90% of the sediments are produced by gully erosion in this area and in effect led to drastic reduction of land availability, crop yield and destruction of ecosystem and other habitats located within the gully.

Heavy rainfall of approximatly 65% normally around July-August alone with very high intensities, usually 70mmhr-1; but as high as 90mm hr-1 during rain storm triggered the formation and development of gully in this area (figure 4). Similarly, since the settlement is located on the hill top extensive flood used to occur at the down slope. Therefore, a lot of the rich top soil is lost to gully erosion, this consequently destroys farmlands, trees and crops these have serious effects on land development, e. g agriculture.



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**Figure 1** Gully showing massive washed out portion in Kargo



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**Figure 2** Part of the gully embankment along Maranjuwa linking Yina to Janbo



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**Figure 3** View of uprooted trees and slumping of gully wall in Kargo



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**Figure 4** Falling and slumping of gully wall in Gandun fawa

Additionally, it has been observed that the mean gully depth were 19.m, gully width,23.5m, and gully length is 134.63m, The nature of the soil is sandy and ranged from white through brown within the gully wall, grasses have also grown inside the gully. It is evident some trees remain suspended along the gully wall indicating imminent disaster and force of the raging flood.

The gully has caused substantial soil losses and water. About 2.15 and 1.18 kg m year $^{-1}$ of soil losses has been apparent. In addition, the resultant soil losses were due to the incident of heavy rainfall over a long period of time and subsequently triggering assembly of sediment at the down slope of the gully. Similarly, a drop of water of approximately 0.3% flowing down the gully has also been observed.

It has been observed that heavy rainfall, flood, rapid soil erosion, wind, gully erosion and human activities through intensive farming practices destroyed several farmlands, trees, crops, roads and bridges. The combined action of these factors led to continuous and rapid dislodgement as well as transportation of soil particles and rock debris which subsequently resulted to land degradation with serious economic effects to the population.

Similarly, since the inception of this threat, the rate, dimension and severity of the attendant problem have proliferate, as no any palliative or remedial action has been put in place to arrest the problem in the aforementioned areas. Therefore, the incident of gully erosion in the study area has generally elicited pre-eminence concern and thus, the imperative necessity of finding comprehensive and lasting solutions to the menace.

## 5. CONCLUSION

The findings of the study indicate that gully erosion is caused mainly due to the action of both natural and anthropogenic factors. The natural factors include heavy rainfall, wind and flood while the anthropogenic factors are deforestation, overgrazing and



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intensive farming practice combine to adversely affect the landscape. About 40% of the land has been fragmented and 25% are caused by gully erosion. It has been observed that the forest cover has been depleted due to the action of both natural and human activities making the area vulnerable to gully erosion, soil erosion, wind and desert encroachment. Grasses of different species grow in and outside the gullies and drop of water of different quantities flowing down the gullies has been observed and thus, facilitates the development of plants. The gullies caused significant soil losses and water largely due the incidence of heavy rainfall over the years and this also encouraged sediment deposition at the down slope of the gullies and channel entrenchment. The study concludes that scientific and remedial action should be put in place to address the issue squarely. The provision of appropriate drainage and channelization is therefore recommended.

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**Conflict of Interest:**
The authors declare that there are no conflicts of interests.

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**Data and materials availability:**
All data associated with this study are present in the paper.

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